MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2018/2019

ETN4106 – OPTOELECTRONICS AND OPTICAL COMMUNICATIONS

(All Sections/Groups)

30 MAY 2019
2.30 p.m. - 4.30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of **FIVE** printed pages (including the cover page) with **FOUR** questions.
2. Answer **ALL** questions.
3. Write your answers in the Answer Booklet.

Question 1 (25 marks)

Table 1 lists the characteristics of Optical Fibers A, B and C and Table 2 shows the attenuation and dispersion value for Optical Fiber A.

Table 1: Characteristics of Optical Fibers A, B and C

Optical Fiber	Numerical aperture (NA)	Core diameter (μm)	Refractive index profile parameter (α)
A	0.14	8.2	-
B	0.20	50.0	-
C	0.20	62.5	2

Table 2: Attenuation and dispersion value for Optical Fiber A

Optical Fiber A	
Attenuation at 1310 nm (dB/km)	0.32
Attenuation at 1550 nm (dB/km)	0.18
Dispersion at 1550 nm (ps/(nm.km))	18.00

(a) Identify and name the three types of optical fibers (Optical Fibers A, B and C) listed in Table 1. [3 marks]

(b) Compare TWO (2) differences between Optical Fibers A and B. [4 marks]

(c) Compare TWO (2) differences between Optical Fibers B and C. [4 marks]

(d) Estimate the number of guided modes in Optical Fibers B and C if the operating wavelength is 1550 nm. Comment on your answer. [9 marks]

(e) If 100 km of Optical Fiber A is used in a point-to-point optical transmission link, what is the total signal attenuation at 1310 nm and 1550 nm? Assume that no connectors or splices are used. Comment on your answer with ONE (1) reason to justify the result. [5 marks]

Question 2 (25 marks)

(a) Propose an optical source, an optical detector and an optical amplifier that are suitable for a long haul optical fiber network operating at the wavelength of 1550 nm. Give ONE (1) reason to support your answer for each type of optoelectronic device chosen. [9 marks]

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Question 2 (continued)

(b) Population inversion is required for optical amplification to occur in a laser.

(i) Describe the term population inversion. Your answer should include the Boltzmann distribution for a system in thermal equilibrium. [4 marks]

(ii) Describe in detail how population inversion can be achieved in a *pn* junction diode. [4 marks]

(c) *pn* junction photodiode and *pin* photodiode are examples of optical detectors.

(i) Describe how a photocurrent is generated in a *pn* junction photodiode. [5 marks]

(ii) Can *pin* photodiodes solve the problems encountered in *pn* junction photodiodes? Justify your answer. [3 marks]

Question 3 (25 marks)

(a) Describe THREE (3) noise sources that may affect the performance of an optical receiver. [6 marks]

(b) Describe the noise current that only occurs in an avalanche photodiode. [3 marks]

(c) A *pin* photodiode in an optical receiver system has a quantum efficiency of 70% when operated at a wavelength of 900 nm. The dark current at this wavelength is 5 nA and the detector capacitance is 7.95 pF. The incident optical power at this wavelength is 180 nW and the post detection bandwidth of the receiver is 5 MHz. Determine:

(i) The mean photocurrent generated. [2 marks]

(ii) The load resistance. [2 marks]

(iii) The rms quantum noise current generated in the photodiode. [3 marks]

(iv) The rms thermal noise in the load resistor at a temperature of 20°C. [3 marks]

(v) The rms dark current noise generated in the photodiode. [3 marks]

(vi) The signal-to-noise ratio (SNR) in dB when the mean photocurrent is the signal. [3 marks]

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Question 4 (25 marks)

Table 3 lists the characteristics of components in Systems A and B.

Table 3: Characteristics of Components in System A and System B

System	Optical source	Optical detector	Optical fiber
A	1 mW fiber-coupled power	-50 dBm sensitivity	3 dB/km attenuation at 850 nm
B	- 13 dBm fiber-coupled power	-38 dBm sensitivity	1 dB/km attenuation at 1310 nm

(a) Assuming a 4 dB system margin, determine the maximum possible transmission distance for System A. You may use a maximum of 4 connectors. Assume that the connector loss is 0.25 dB/connector. [5 marks]

(b) Assuming a 4 dB system margin, determine the maximum possible transmission distance for System B. You may use a maximum of 4 connectors. Assume that the connector loss is 0.25 dB/connector. [5 marks]

(c) Propose TWO (2) methods to increase the transmission distance for both System A and System B. Justify your answer. [4 marks]

(d) You are required to design a communication system with a transmission distance of 40 km by using only components from Systems A and B. Assume that the components from Systems A and B can be used for wavelengths of 850 nm and 1310 nm.

(i) Based on Table 3, which optical fiber would you select? Justify your answer. [2 marks]

(ii) Based on Table 3, which optical source would you select? Justify your answer. [2 marks]

(iii) Based on Table 3, which optical detector would you select? Justify your answer. [2 marks]

(iv) From your selection of components in Question 4 (d)(i)-(iii), calculate the system margin of your system. Assume there are no losses due to connectors in your calculation. [5 marks]

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Appendix A

Physical Constants and Units

Constant	Symbol	Value (mks units)
Speed of light in vacuum	c	2.998×10^{8} m/s
Electron charge	e	1.602×10^{-19} C
Boltzmann's constant	k_B	1.38×10^{-23} J/K
Permittivity of free space	ε_0	8.8542×10^{-12} F/m
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ N/A^2
Electron volt	eV	1 eV = 1.602×10^{-19} J
Planck's constant	h	6.626×10^{-34} J·s

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